coupled to a volt meter and connected to the test lead station, pipe/soil potentials can be obtained. A negative voltage between −1.2 vdc and −0.85 vdc is generally considered acceptable. Most CPRs are monitored for voltage, amperage and meter readings. Cathodic test lead stations are typically positioned at one-mile intervals, or at stations of easy access, e.g., pipeline warning sign locations and road crossing locations. Operators routinely visit these cathodic test lead stations at monthly intervals to obtain pipe/soil potentials, thereby ensuring reliability of the cathodic protection system.

Contractors digging close to pipelines may inadvertently damage a pipeline. Damage to the pipe protective wrapping often leads to corrosion, which is the major cause of pipeline leaks or blowouts. Also, attacks to the pipeline by terrorists or illegal tapping of the pipe contents can cause severe disruption to the pipeline system.

Obtaining monthly data cathodic test lead stations is labor intensive, and prevents technicians from performing other pipeline duties. Moreover, this labor intensive staff typically experience long driving hours under variable weather conditions. Pipeline operators recognize that many driving accidents occur in the pipeline industry because of the need to periodically monitor the cathodic test lead stations.

The disadvantages of the prior art are overcome by the present invention, and the improved pipeline monitoring system is hereafter disclosed.

SUMMARY OF THE INVENTION

A pipeline monitoring system according to a preferred embodiment includes a series of monitoring stations positioned along a pipeline. Each monitoring station is capable of communicating with a central monitoring facility, both for transmitting commands to the monitoring station and for receiving monitoring signals at the central monitoring facility. The monitoring station may be responsive either to a command from the central monitoring station, or to a computer with a pre-programmed event time at the monitoring station, or to a magnetic pig detected at the monitoring station as it is passed through the pipeline.

Each monitoring station may include a computer, a communications modem, input/output modules and a magnetic sensing module. The computer is adapted to receive a number of input/output modules which are individually configured to interface to a wide variety of measuring instruments and control equipment for the measurement of, e.g., pipeline pig detection, pipe/soil potentials, pipeline damage detection, CPR current, voltage, and meter readings, and valve monitoring and activation. The communication module interfaces the monitoring station to the central monitoring facility through a satellite communications network, preferably the Low Earth Orbiting (LEO) satellite system, so that the pipeline can be monitored in real time without requiring technicians at each monitoring station.

It is an object of the present invention to provide an improved method of monitoring magnetic pipeline pigs and/or obtaining pipe/soil potentials and/or detecting pipeline damage, thus saving pipeline operators labor and reducing driving accidents.

It is a feature of the present invention that each monitoring station includes a satellite communications module for interfacing with a LEO satellite system. A related feature of the invention is that the central monitoring facility includes a control station to output command signals to the plurality of monitoring stations. Each of the plurality of monitoring stations may also include a computer for outputting an activity signal to operate the monitoring station.

Another feature of the invention is that the satellite communications module outputs a time signal in response to the magnetic pig position detector, so that the central monitoring facility may easily determine the location and the speed of the pig moving through the pipeline. The pipeline monitoring system may also include digital-to-analog converters, analog-to-digital converters, and a reset circuit for applying opposite current pulses to the magnetic pig position detector.

Still another feature of the invention is that satellite communication module outputs pipe/soil potentials at periodic intervals to the central monitoring facility. Pipe/soil potentials from the number of monitoring stations may be obtained substantially simultaneously, so that comparisons between potentials at different locations can be analyzed. Pipe/soil potentials may alternatively be output sequentially or upon command from the central monitoring facility, so that a pipe/soil potential may be obtained each day of the month from one of the 30 monitoring stations.

Still another feature of the invention is that the potential pipeline damage signal may be generated, e.g., by a geophone or a vibration detector, and the potential pipeline damage signal transmitted through the satellite communications module to a central monitoring facility. This feature of the invention provides significant safety for pipeline operations to minimize damage from accidents or terrorism.

Another feature of the invention is that the pipeline monitoring system is reliably able to monitor various pipeline operations, including the position of a valve, pressure and temperature of a fluid in the pipeline, monitoring the flow of fluid in the pipeline, and sensing one or more of CPR current, CPR voltage, and CPR meter readings. The pipeline system is also able to actuate devices at the monitoring station, e.g., activating a valve in response to instructions from the central monitoring facility,

Another feature of the invention is that the satellite communications module may be housed within a pipeline marker. A power source may be provided at each monitoring station to power the satellite communications module. In a subsea environment, a buoy is provided for supporting the satellite communications module, and transmission means are provided for transmitting a signal from the magnetic pig position detector from subsea to the satellite communications module.

According to the method of the invention, the passage of a magnetic pig is detected at each of the plurality of monitoring stations, and a signal output from the satellite communications module to the central monitoring facility indicates the passage of the pig. Pipe/soil potentials may be detected at a pre-programmed time and a voltage signal output through a satellite communications module. A damage alert module, when activated, will send a potential pipe damage signal to the central monitoring facility through the satellite communications module. The central monitoring facility may determine the speed of the magnetic pig moving through the pipeline, and estimate the arrival of the magnetic pig at another monitoring station. The central monitoring facility may generate command signals which are forwarded to a satellite communications module to operate each of the plurality of stations. If desired, a valve may be actuated in response to the detection of a passage of the magnetic pig.

A significant advantage of the present invention is that the cost of monitoring pipeline operations is significantly